T-BEST 2.1

Presented to:
ESRI International User Conference
July 27, 2005
Project Team

- Florida Department of Transportation, Public Transit Office
- Center for Urban Transportation Research (CUTR)
- University of South Florida
- GeoDecisions, A Division of Gannett Fleming
- Gannett Fleming, Inc.
Outline

1. Need for T-BEST
2. T-BEST Applications
3. T-BEST Model Concepts
4. T-BEST Analysis
5. T-BEST Software Overview
6. T-BEST Implementation
7. Conclusions
8. Future Enhancements
9. Demonstration
Need For T-BEST

- Systems Planning Software
  - Traditional 4 Step Planning Travel Models
  - Long term (20+years), Systems Level
  - Multimodal
  - Primarily Suited for Major Investment Studies
Need For T-BEST

- Transit Operational Level Software
  - Trapeze, Hastus
  - Routing & Scheduling
  - Do Not Allow for Evaluation of Service Alternatives
T-BEST Applications

What is T-BEST?

- **Comprehensive Transit Network Modeling, Management and Analysis Software designed for short-term transit planning**
- **Direct and Transfer Stop-Level Boardings Estimation**
T-BEST Applications

- **Service Planning**
  - Stop/Route Adjustments based on:
    - Seasonal Patterns
    - Land Use Changes
    - Road Construction
    - Service Changes
  - Short-Term Ridership Forecasting
  - Adjust Socio-Economic for expected growth
  - Fare Structure changes
  - New Routes, Stops
  - New Technologies (BRT, Rail, Trolley, etc)
T-BEST Applications

- Support for Transit Development Plans
- Transit System Management
  - Network Editing/Coding
  - Integration with ArcGIS
  - Can serve as a baseline operational software
Transit systems planning considerations:

- Accessibility
- Availability
- Quality of Service
- Ridership
- Temporal Characteristics
- Transfers
- Route/Network Design
- Fare Policies and Structure
- Alternative Modal Options/Technologies/Route Types
- Disaggregate Stop-Level Analysis
T-BEST Model Concepts

- Transit ridership strongly affected by:
  - Destination accessibility
  - Temporal availability
  - Network connectivity

- Desire to have T-BEST sensitive to all three aspects of transit accessibility

- Ability to test effects of alternative route and network design configurations on transit boardings
T-BEST Model Concepts

Neighboring Stops

- Riders may choose alternative stops, routes, destinations for pursuing activities
- Neighboring stops effectively capture effects of competing routes/stops
- Neighboring stops are those with overlapping buffers with subject stop
  - N1: Same Route, Same Direction
  - N2: Same Route, Opposite Direction
  - N3: Other Routes, Similar Destinations
T-BEST Model Concepts

Network Accessibility Measures

- $H_1$: Stops from which one can reach the N3 neighboring stops (Interest: Feeders for potential transfers)
- $H_2$: Downstream stops that can be reached from subject stop via the transit network (Interest: Capture potential downstream activities)
- $H_3$: Upstream stops that can be reached from the N2 stops (Interest: Capture potential upstream activities)
- $H_4$: Stops that can be reached from the N3 neighboring stops (Interest: Capture potential activities on other routes)
- $H_5$: Stops in $H_4$ that overlap with stops in $H_3$ (Interest: Capture potential competing activities)
T-BEST Model Concepts

- Computing Transit Accessibility
  - Access / Egress at Given Stop
  - Accessibility to Other Stops
- Composite Impedance Factors
  - Wait Time
  - Boarding Time
  - In-vehicle Time
  - # of Transfers
  - Transit Walking Time
  - Transfer Fare
T-BEST Model Concepts

- Estimate Boardings at a Stop by:
  - Route
  - Direction
  - Time Period

- Model Estimates two Boarding Types:
  - Direct (Walk, Bike & Auto Access)
  - Transfer (Transit Access)
T-BEST Model Concepts

Direct Boarding Equation

\[ D_n^s = f(R_n^s, B_n^s, O_{2n}^s, O_{3n}^s, O_{4n}^s, O_{5n}^s, X_n^s) \]

- \( s \) refers to stop on a route in a given direction and
- \( n \) refers to time period
- \( D = \) direct boardings
- \( R = \) number of bus runs (arrivals)
- \( B = \) vector of buffer characteristics (population/employment)
- \( O_i = \) accessibility measures = characteristics of buffer areas of accessible stops, \( H_i, i = 2, 3, 4, 5 \)
- \( X = \) vector of other route and stop characteristics

\( n = 1, \ldots, N \)
T-BEST Model Concepts

Transfer Boarding Equation

\[ T^S_n = g(R^S_n, O^S_{1n}, O^S_{2n}, O^S_{3n}, O^S_{4n}, O^S_{5n}, Y^S_n) \quad n = 1, \ldots, N \]

- \( T \) = transfer boardings
- \( R \) = number of bus runs (arrivals)
- \( O_1 \) = accessibility measure = total boardings at all stops, \( H_1 \), during period \( n \) toward stop \( S \)
- \( Y \) = vector of other route and stop characteristics

Methodology thus includes both direct and transfer boardings equations

Accessibility vectors play major role
T-BEST Model Concepts

T-BEST Data Requirements

- Transit Route & Stops Location
- Transit Route Schedule
- Transit Route & Stop Names
- Transit System
  - Fare Structure
  - Transfer Hubs
  - Interlined Routes
T-BEST Model Concepts

T-BEST Data Requirements

- Florida Source Data provided with the software:
  - 2000 Census data with pre-formatted SF1 and SF3 variables
  - 2000 InfoUSA Employment data grouped by Commercial, Industrial, and Service
  - 2000 GDT Street Networks
  - Other background GIS layers
T-BEST Analysis

Model Outputs

- T-BEST Calculates
  - Direct + Transfer = Total Boardings
  - Arrivals
  - Transfer Opportunities

- Time-Period Specific Estimations
  - Peak
  - Off-Peak
  - Night
  - Saturday
  - Sunday

- Aggregate Model Outputs by:
  - Weekday
  - Weekend
  - All Time Periods
# T-BEST Analysis

## Time Period Aggregation

### Example:

- **Route 101**
- Inbound Stop #10161000

### Model Results by Time Period

<table>
<thead>
<tr>
<th>Time Period Aggregate Results</th>
<th>Peak</th>
<th>Off-Peak</th>
<th>Night</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Boardings</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Time Period</td>
<td>Weekday = 11</td>
<td></td>
<td></td>
<td>Weekend = 4</td>
<td></td>
</tr>
<tr>
<td>All Time Periods</td>
<td>All Time Periods = 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
T-BEST Analysis

Route Level Aggregation Outputs

- Performance Measures
  - Boardings
  - Route / Service Miles
  - Service Hours
  - Boarding per Service Mile / Hour
  - Average Boarding per Service Run

- Aggregation by:
  - Route Type
  - Technology
  - Report on All Routes = System-wide Analysis
T-BEST Analysis

Area-Based Aggregation

- Summarize Model Results with a Polygon Shapefile (Districts, TAZ, Census Blocks, etc.)
- User-Defined Global Subareas
  - Analyze Model Output across multiple Scenarios
T-BEST Analysis

T-BEST Reports

- Calculates Sub-Totals by Route or Planning Area
- Total for all selected inputs (stop, route, area)
- Automatic Map Display Stop-level boardings (pie chart) or area distribution
T-BEST Software

Comprehensive Model System

- Manage Multiple Transit Systems
- Scenario/Alternative Management Tools
- Update Base Year Model
- Internal Model Runs
- Unlimited Analysis potential
T-BEST Software

Transit System Management

- Create new Transit Systems
- Manage Existing Transit Systems
- Delete Systems
- All Files/Data managed internally in the software
T-BEST Software

Scenario/Alternative Management

- Manage Alternatives
- Create Base Year Model
- Adjust Socio-Economic Variables to Future Year
- Incorporate Local Employment Data
T-BEST Software

System Properties

- Fare Structure
- Transfer Hubs
- Interlined Routes
- Local Employment Data
- Socio-Economic growth applied to future year forecasts
T-BEST Software

Scenario Editor

- Integrated editing, coding and analysis environment
- GIS-enabled network editing
- Time Period specific variables
- Stop-level socio-economic updates
T-BEST Software

GIS Features

- T-BEST developed with ArcObjects
- Add local data or images
- Edit Symbols and Labels
- Save custom Map setup with Scenario
Model Equations

- Edit Direct and Transfer Boarding Coefficients
## T-BEST Software

## Interactive Reporting

### Aggregate Records by:
- **Route(s)**
- **Sub-Area**
- **Selection Set**
- **Planning Area**

### Route-level Performance Measures

### Boardings Estimation

<table>
<thead>
<tr>
<th>ROUTE</th>
<th>TRANSFER OPPORTUNITIES</th>
<th>DIRECT BOARDINGS</th>
<th>TRANSFER BOARDINGS</th>
<th>TOTAL BOARDINGS</th>
<th>REVENUE SERVICE TRIPS</th>
<th>REVENUE SERVICE MILES</th>
<th>REVENUE SERVICE HOURS</th>
<th>BOARDINGS PER SERVICE MILE</th>
<th>BOARDINGS PER SERVICE HOUR</th>
<th>BOARDINGS PER SERVICE TF</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS 34(A)</td>
<td>545</td>
<td>69</td>
<td>14</td>
<td>88</td>
<td>4</td>
<td>10.5</td>
<td>42</td>
<td>2</td>
<td>20.96</td>
<td>20.96</td>
</tr>
<tr>
<td>WS 38(B)</td>
<td>129</td>
<td>40</td>
<td>22</td>
<td>62</td>
<td>4</td>
<td>10.3</td>
<td>41</td>
<td>1.52</td>
<td>15.6</td>
<td>15.6</td>
</tr>
<tr>
<td>WS 54(A)</td>
<td>277</td>
<td>20</td>
<td>24</td>
<td>61</td>
<td>4</td>
<td>9.4</td>
<td>30</td>
<td>1.02</td>
<td>20.47</td>
<td>15.36</td>
</tr>
<tr>
<td>WS 54(B)</td>
<td>762</td>
<td>50</td>
<td>34</td>
<td>84</td>
<td>4</td>
<td>10.4</td>
<td>40</td>
<td>2.01</td>
<td>20.08</td>
<td>20.08</td>
</tr>
<tr>
<td>WS 54(C)</td>
<td>568</td>
<td>62</td>
<td>17</td>
<td>79</td>
<td>8</td>
<td>12.8</td>
<td>96</td>
<td>6.93</td>
<td>8.61</td>
<td>9.91</td>
</tr>
<tr>
<td>WS 78(A)</td>
<td>615</td>
<td>47</td>
<td>21</td>
<td>68</td>
<td>5</td>
<td>11.8</td>
<td>71</td>
<td>5.96</td>
<td>11.4</td>
<td>11.4</td>
</tr>
<tr>
<td>WS 78(B)</td>
<td>271</td>
<td>36</td>
<td>11</td>
<td>49</td>
<td>4</td>
<td>9.2</td>
<td>37</td>
<td>1.32</td>
<td>16.33</td>
<td>12.24</td>
</tr>
<tr>
<td>WS 78(B)</td>
<td>638</td>
<td>49</td>
<td>22</td>
<td>71</td>
<td>4</td>
<td>10.7</td>
<td>43</td>
<td>1.54</td>
<td>12.56</td>
<td>17.56</td>
</tr>
<tr>
<td>WS 78(A)</td>
<td>663</td>
<td>34</td>
<td>27</td>
<td>105</td>
<td>4</td>
<td>11.4</td>
<td>44</td>
<td>2.29</td>
<td>25.96</td>
<td>25.96</td>
</tr>
<tr>
<td>WS 78(A)</td>
<td>783</td>
<td>37</td>
<td>31</td>
<td>68</td>
<td>4</td>
<td>10.5</td>
<td>40</td>
<td>1.61</td>
<td>16.92</td>
<td>16.92</td>
</tr>
<tr>
<td>WS 34(A)</td>
<td>307</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3.7</td>
<td>28</td>
<td>0.22</td>
<td>2.18</td>
<td>2.18</td>
</tr>
<tr>
<td>WS 34(B)</td>
<td>315</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>12.5</td>
<td>38</td>
<td>0.36</td>
<td>4.82</td>
<td>4.82</td>
</tr>
<tr>
<td>WS 37(A)</td>
<td>807</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WS 37(B)</td>
<td>75</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.61</td>
</tr>
<tr>
<td>NS 34(A)</td>
<td>320</td>
<td>35</td>
<td>17</td>
<td>52</td>
<td>4</td>
<td>6.5</td>
<td>5</td>
<td>0.99</td>
<td>10.76</td>
<td>9.97</td>
</tr>
<tr>
<td>NS 54(A)</td>
<td>127</td>
<td>45</td>
<td>17</td>
<td>62</td>
<td>5</td>
<td>8.1</td>
<td>23</td>
<td>1.46</td>
<td>16.27</td>
<td>11.87</td>
</tr>
<tr>
<td>NS 54(B)</td>
<td>267</td>
<td>21</td>
<td>27</td>
<td>58</td>
<td>3</td>
<td>6.3</td>
<td>57</td>
<td>1.01</td>
<td>11.51</td>
<td>6.33</td>
</tr>
<tr>
<td>NS 54(C)</td>
<td>183</td>
<td>93</td>
<td>22</td>
<td>115</td>
<td>2</td>
<td>5.8</td>
<td>159</td>
<td>1.21</td>
<td>13.35</td>
<td>13.52</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>283</td>
<td>97</td>
<td>77</td>
<td>174</td>
<td>13</td>
<td>6.8</td>
<td>58</td>
<td>7.2</td>
<td>23.48</td>
<td>13.7</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>895</td>
<td>178</td>
<td>69</td>
<td>238</td>
<td>13</td>
<td>9.1</td>
<td>119</td>
<td>2.01</td>
<td>21.71</td>
<td>18.87</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>180</td>
<td>72</td>
<td>63</td>
<td>138</td>
<td>12</td>
<td>7.8</td>
<td>90</td>
<td>1.5</td>
<td>16.64</td>
<td>11.22</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>324</td>
<td>124</td>
<td>26</td>
<td>150</td>
<td>9</td>
<td>10.9</td>
<td>87</td>
<td>1.03</td>
<td>18.53</td>
<td>18.53</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>560</td>
<td>62</td>
<td>69</td>
<td>190</td>
<td>9</td>
<td>10.2</td>
<td>32</td>
<td>1.09</td>
<td>10.76</td>
<td>10.76</td>
</tr>
<tr>
<td>NS 78(B)</td>
<td>262</td>
<td>67</td>
<td>29</td>
<td>96</td>
<td>8</td>
<td>7.2</td>
<td>58</td>
<td>1.66</td>
<td>19.24</td>
<td>12.02</td>
</tr>
<tr>
<td>NS 78(B)</td>
<td>518</td>
<td>66</td>
<td>50</td>
<td>117</td>
<td>9</td>
<td>8.4</td>
<td>76</td>
<td>1.53</td>
<td>16.96</td>
<td>12.96</td>
</tr>
<tr>
<td>NS 78(C)</td>
<td>402</td>
<td>49</td>
<td>31</td>
<td>81</td>
<td>4</td>
<td>11.1</td>
<td>45</td>
<td>1.78</td>
<td>20.21</td>
<td>20.27</td>
</tr>
<tr>
<td>NS 78(C)</td>
<td>863</td>
<td>33</td>
<td>45</td>
<td>78</td>
<td>4</td>
<td>11.1</td>
<td>44</td>
<td>1.78</td>
<td>20.21</td>
<td>20.27</td>
</tr>
<tr>
<td>NS 78(C)</td>
<td>234</td>
<td>22</td>
<td>20</td>
<td>42</td>
<td>12</td>
<td>4.4</td>
<td>56</td>
<td>1.5</td>
<td>18.55</td>
<td>7.73</td>
</tr>
<tr>
<td>NS 78(C)</td>
<td>712</td>
<td>50</td>
<td>4</td>
<td>54</td>
<td>3</td>
<td>6.3</td>
<td>25</td>
<td>1.78</td>
<td>19.02</td>
<td>11.1</td>
</tr>
<tr>
<td>NS 78(A)</td>
<td>116</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WS 54(A)</td>
<td>814</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WS 54(B)</td>
<td>241</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WS 54(C)</td>
<td>102</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Gannett Fleming
T-BEST Software

Analysis Mapping

- Automated Map Analysis
- Flexible Mapping Environment
T-BEST Software

Quality Control Measures

- Visualize Model
- Accessibility Calculations with impedance (H1-H5)
- Locate Neighboring Stops (N1 – N3)
- Shortest Path Algorithm
Model Engine

- Time Period Specific output for each stop
- Option to run for selected time periods
- Optimized model calculations to run only necessary components
Additional Features

- Direct conversion of T-BEST Map into ArcMap Layout
- Export all Reports or lists to delimited text files
- Export Map to raster or PDF
- Save Sub-Areas and Selection Sets for use in multiple Scenarios
- Scenario Log
- Extensive User-Guide
T-BEST Implementation

Default Implementation

- Download & Install Software (www.tbest.org)
- Default coefficients provided
  - Calibration for Portland, Oregon in progress
- Calibration to Local Area
  - Local Stop Level Ridership Data
  - Develop Socio-Economic data
  - Create T-BEST Transit Network
  - Re-estimate and Re-calibrate
T-BEST Implementation

Custom Implementation

- Software
- Data Model
- Interface with Systems Planning and Operational Software
- Scale T-BEST to your Enterprise Environment

<table>
<thead>
<tr>
<th>Database</th>
<th>Network Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle</td>
<td>Oracle Spatial</td>
</tr>
<tr>
<td>SQL Server</td>
<td>SDE</td>
</tr>
</tbody>
</table>
T-BEST Implementation

- **Recommended Hardware**
  - 2.0 GHz Pentium M Processor or higher
  - 1 GB Ram

- **Required Software**
  - Windows 2000 or XP
  - ArcView 9.x
Conclusions

- T-BEST provides a powerful framework for modeling transit ridership at stop level
- Incorporates effects of accessibility and connectivity on ridership
- Accessibility and impedance computations very sophisticated, accurate, and automated in software
- More precisely accommodates effects of service span and frequency (temporal aspects)
- Focus on ease of use and quick response capability
Future Enhancements

- Enhancements for T-BEST 3.0:
  - Automated calibration and scaling procedures
  - T-BEST Analyzer
  - Enhance stop-level accessibility measure using alternative methodologies (e.g., network-based, regression, TLOS)
  - Statewide Transit Network Input
Future Enhancements

- Enhancements for T-BEST 4.0:
  - Develop sets of equations for different urban area sizes and trip purposes
  - Spatial distribution of boardings to develop a stop-to-stop O-D matrix
  - Greater sensitivity to route type, technology type, park-n-ride facilities, and special generators
Questions??